USGS
science for a changing world

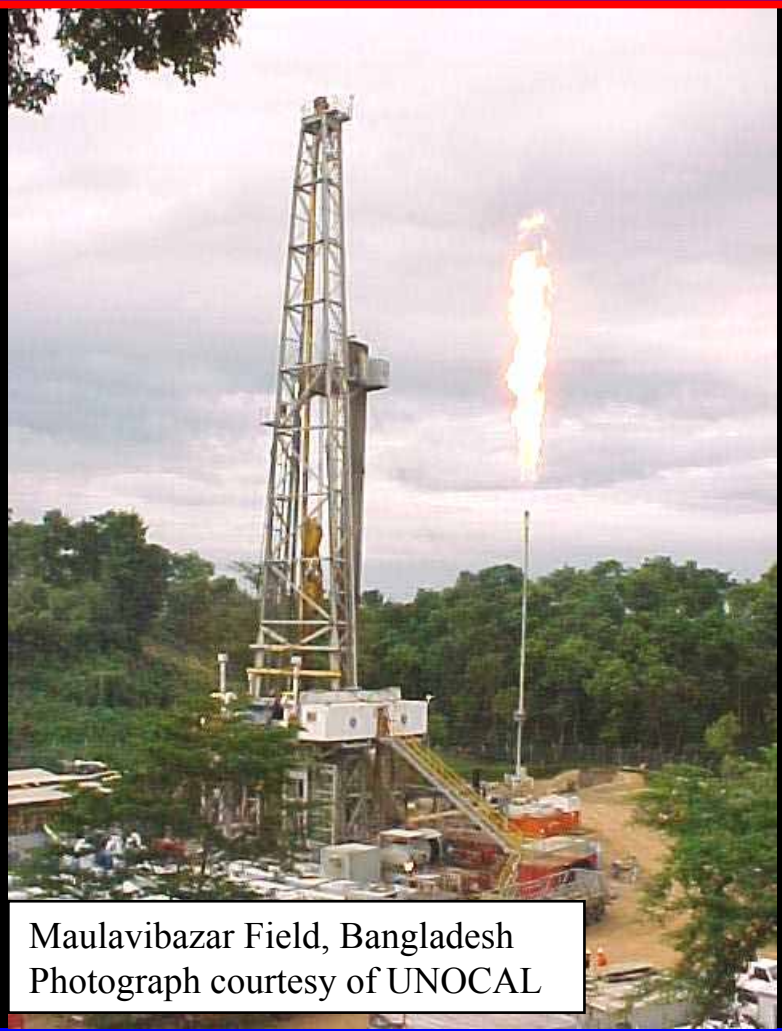
Future Petroleum Supply – Exploration or Development?

T.R. Klett
U.S. Geological Survey

Norwegian Geological Society
Stavanger, Norway
June 1, 2004

Future Petroleum Supply

Exploration or Development



Maulavibazar Field, Bangladesh
Photograph courtesy of UNOCAL

- Additions to reserves
  - Exploration
    - New-field discoveries
  - Development of existing fields
    - Reserve growth

Future Petroleum Supply

Exploration or Development

Taft, California
Photograph courtesy of Ken Takahashi, USGS

- Volumes of petroleum added to reserves by field development are comparable to those added by new-field discoveries!

Future Petroleum Supply

Exploration or Development

Hassi Messaoud Field, Algeria

- Exploration
  - Accessibility
  - Significant capital
  - Risks
    - Economic
    - Technological
    - Environmental
    - Political

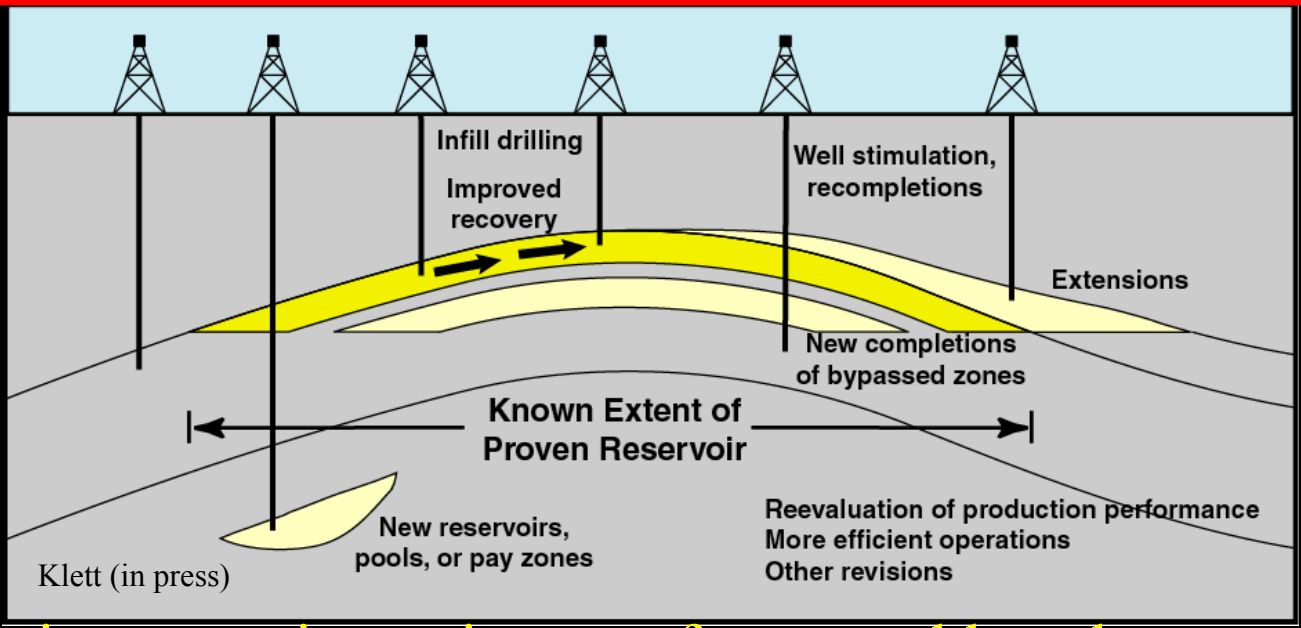
Future Petroleum Supply

Exploration or Development

Jalalabad Field, Bangladesh
Photograph courtesy of UNOCAL

- Development
  - More cost effective than exploration
  - Risks
    - Technological
    - Environmental
  - Finite volumes

Reserve Growth
Definition



Increases in successive estimates of recoverable volumes of crude oil, natural gas, and natural-gas liquids in discovered fields

- Delineation of additional in-place volumes (geologic)
- Increases in recovery efficiency (engineering)
- Recalculation of viable reserves in dynamically changing conditions
  - Economic, operating (technological), and political/regulatory

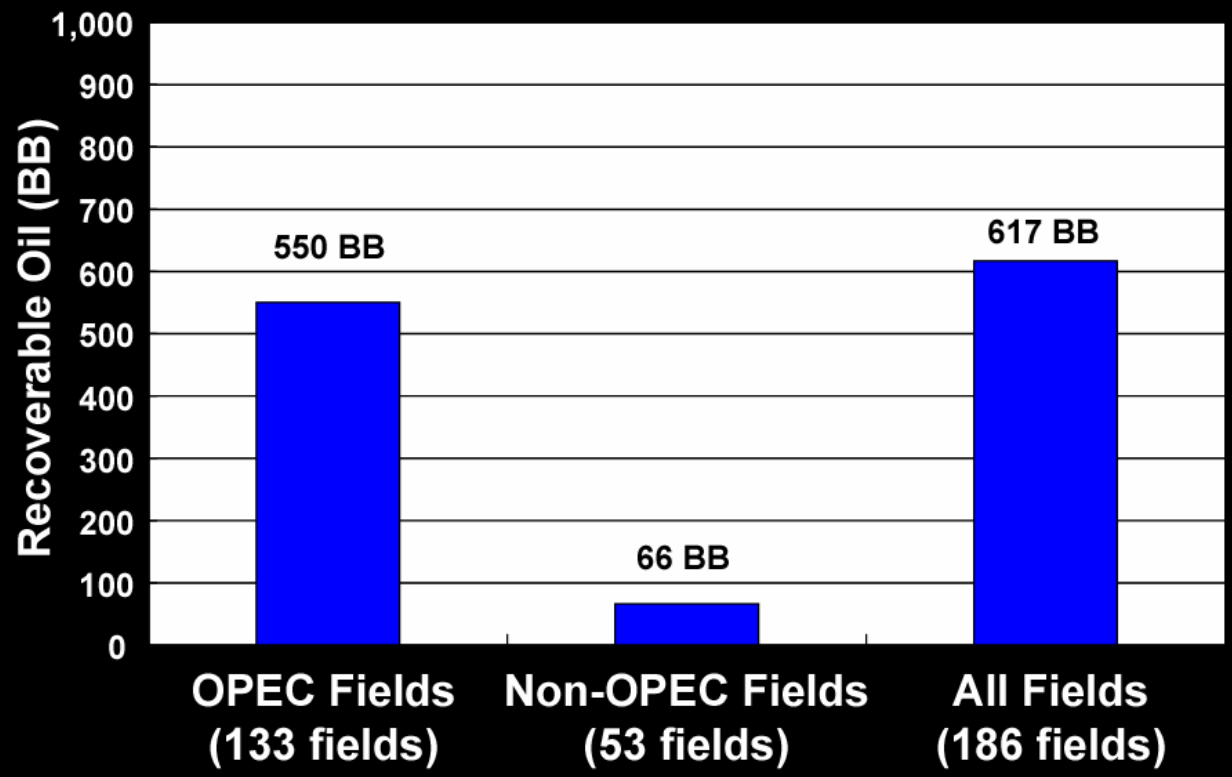
Reserve Growth

- Studied initially for U.S. assessments
- Address reserve growth in World Petroleum Assessment 2000
  - Test hypothesis that reserve growth is not only a U.S. phenomenon
    - U.S. history, SEC regulations
    - Databases
  - "Reserve Growth of the World's Giant Oil Fields" (Klett and Schmoker, 2003)

Reserve Growth

Magnitude

Recoverable Oil in 186 Giant Oil Fields (≥ 0.5 BB), Reported in 1981



From Klett and Schmoker (2001, 2003); Klett, Charpentier, Schmoker, and Attanasi (2000)

Data from IHS Energy Group (1981 to 2003)

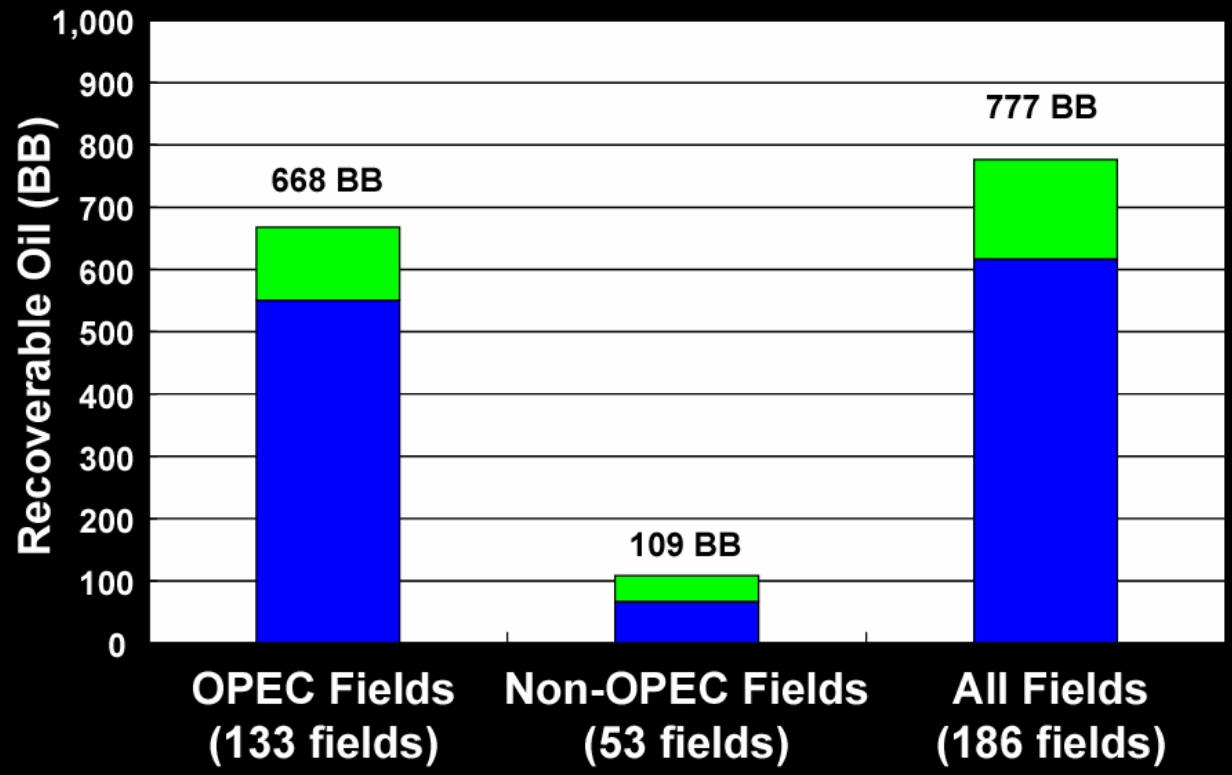
USGS

The 186 giant oil fields contain 50% of the world's recoverable crude oil (excluding U.S. and Canada)

Reserve Growth

Magnitude

Recoverable Oil in 186 Giant Oil Fields, Reported in 1996 (15 years)



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Data from IHS Energy Group (1981 to 2003)

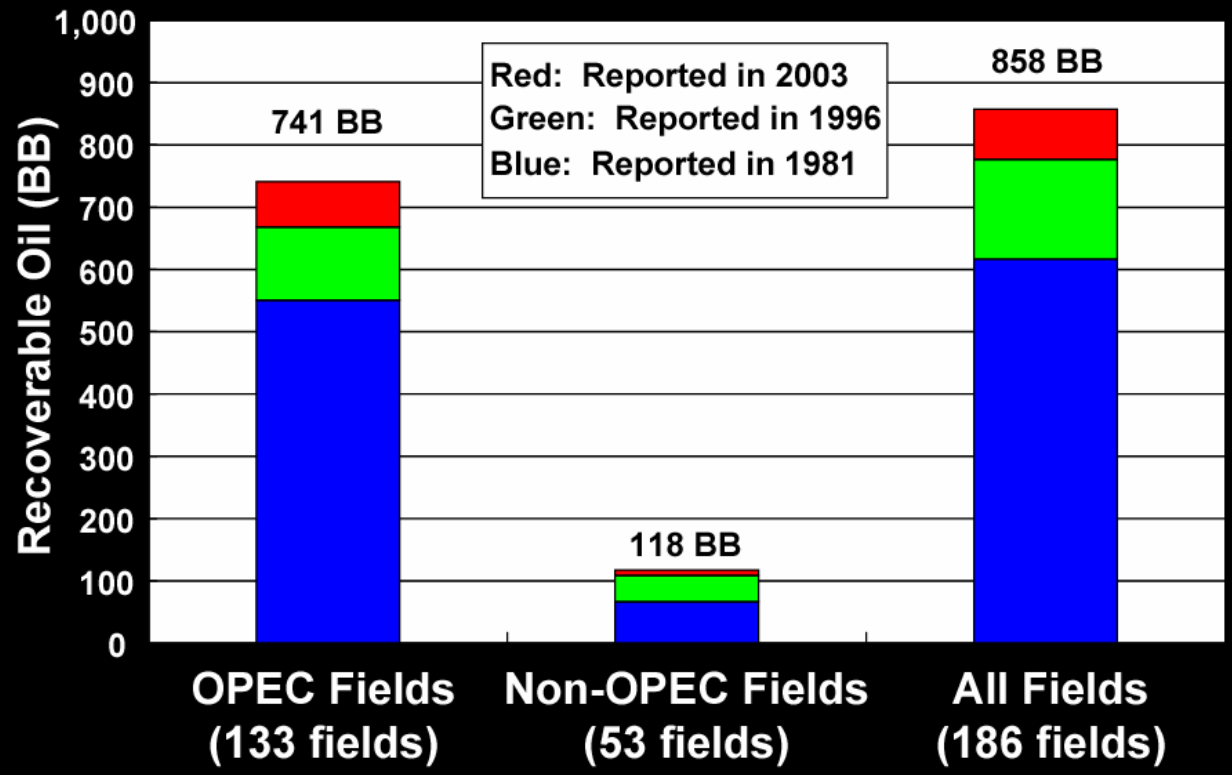
USGS

The 186 giant oil fields contain 50% of the world's recoverable crude oil (excluding U.S. and Canada)

Reserve Growth

Magnitude

Recoverable Oil in 186 Giant Oil Fields, Reported in 2003 (22 years)



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Data from IHS Energy Group (1981 to 2003)

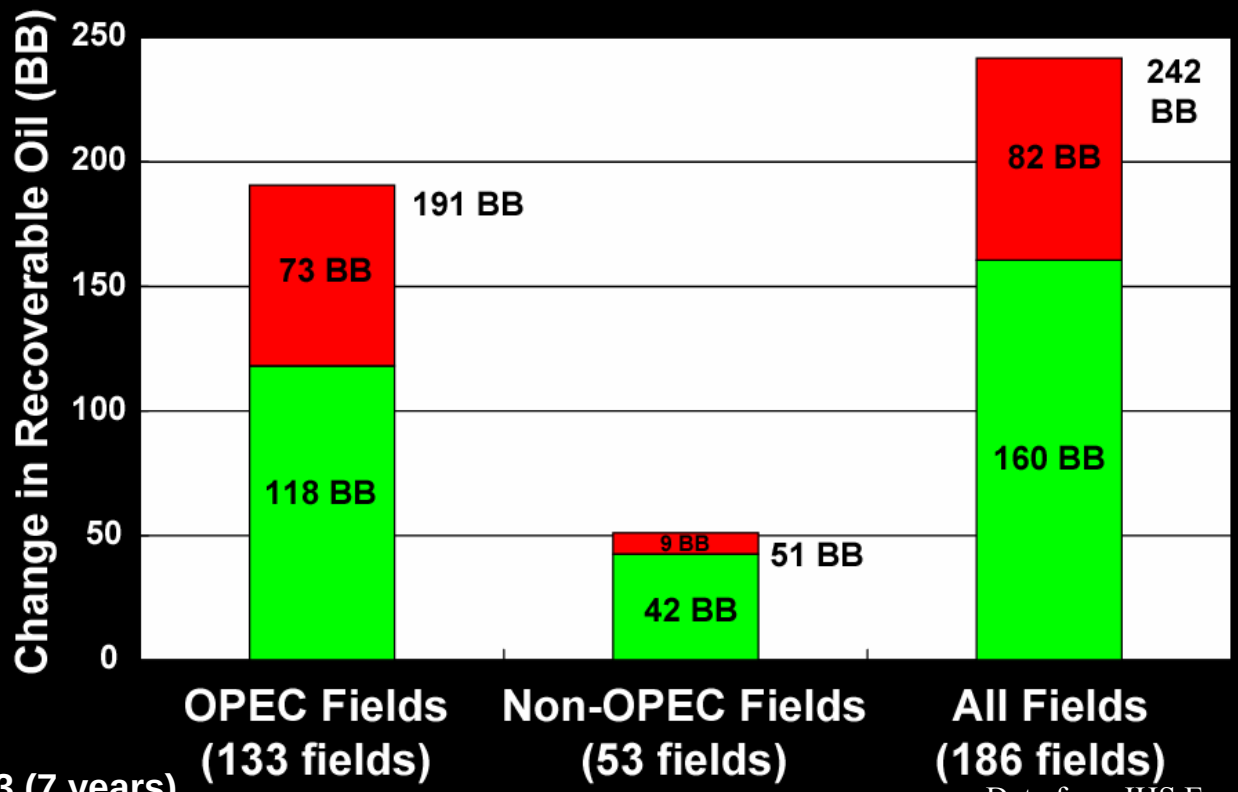
USGS

The 186 giant oil fields contain 50% of the world's recoverable crude oil (excluding U.S. and Canada)

Reserve Growth

Magnitude

Net Change in Recoverable Oil in 186 Giant Oil Fields, 1981 to 2003



Red: 1997 to 2003 (7 years)
Green: 1981 to 1996 (15 years)

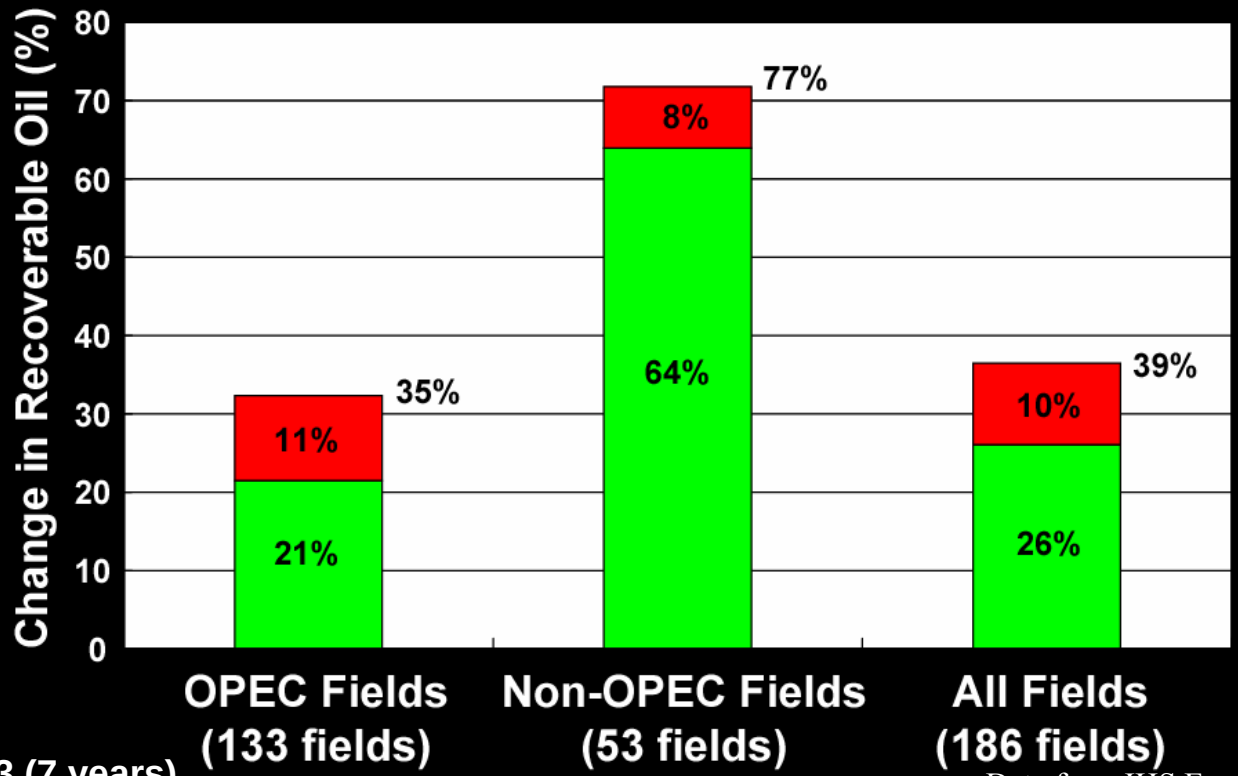
Data from IHS Energy Group (1981 to 2003)

From Klett and Schmoker (2001, 2003); Klett, Charpentier, Schmoker, and Attanasi (2000)

Reserve Growth

Magnitude

Percent Change in Recoverable Oil, Relative to Volumes Reported in 1981, in 186 Giant Oil Fields, 1981 to 2003



Red: 1997 to 2003 (7 years)
Green: 1981 to 1996 (15 years)

Data from IHS Energy Group (1981 to 2003)

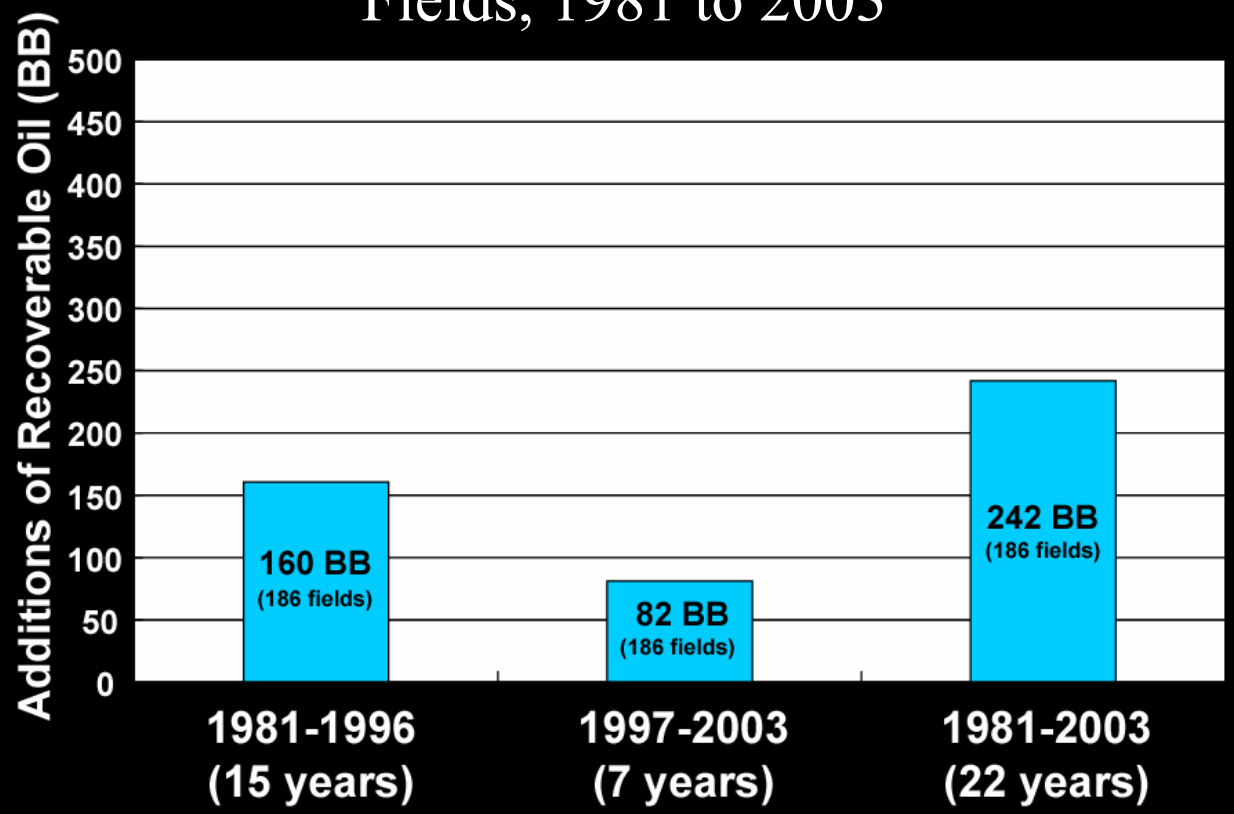
From Klett and Schmoker (2001, 2003); Klett, Charpentier, Schmoker, and Attanasi (2000)

USGS

Reserve Growth

Magnitude

Additions to Reserves, Net Change in Recoverable Oil in 186 Giant Oil Fields, 1981 to 2003

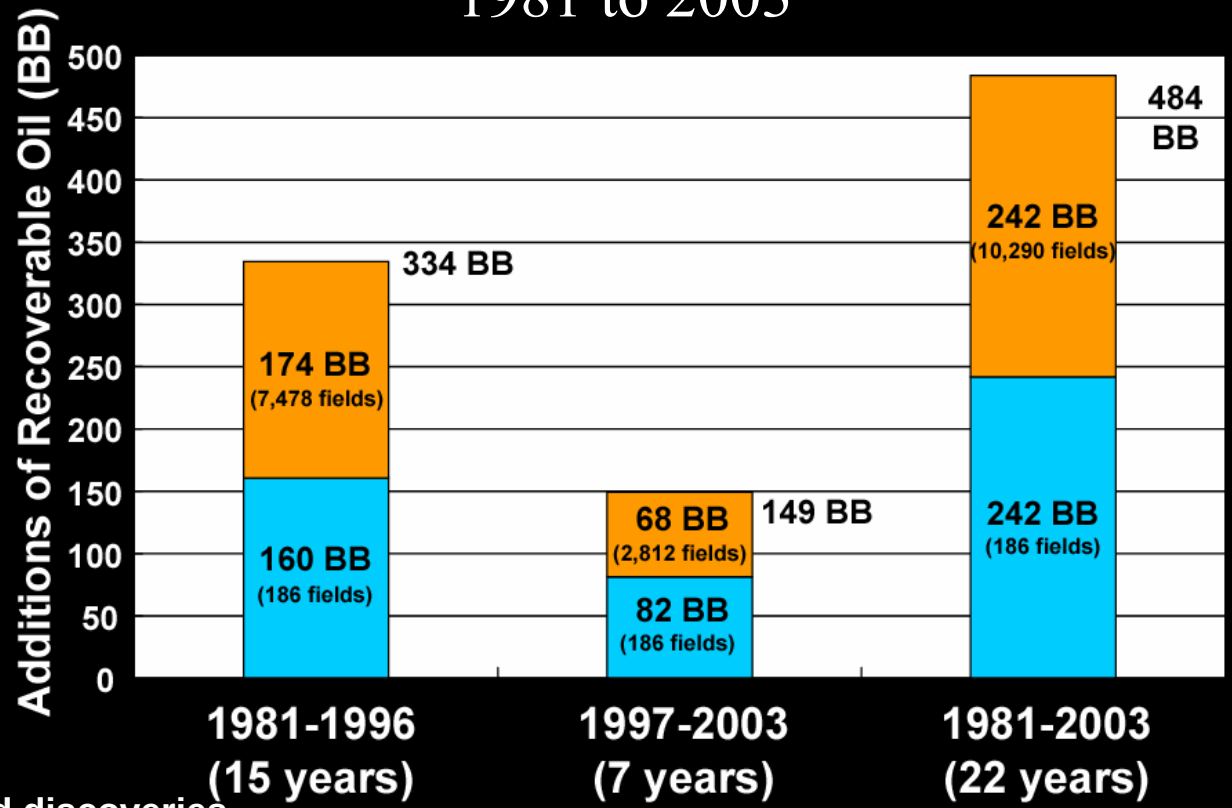


From Klett and Schmoker (2001, 2003); Klett, Charpentier, Schmoker, and Attanasi (2000) Data from IHS Energy Group (1981 to 2003)

Reserve Growth

Magnitude

Additions to Reserves, Reserve Growth and New-Field Discoveries, 1981 to 2003



Orange: New-field discoveries
Blue: Change in recoverable oil in 186 giant oil fields

Data from IHS Energy Group (1981 to 2003)

USGS

Volumes added to reserves in 186 giant oil fields equals volumes added from new-field discoveries

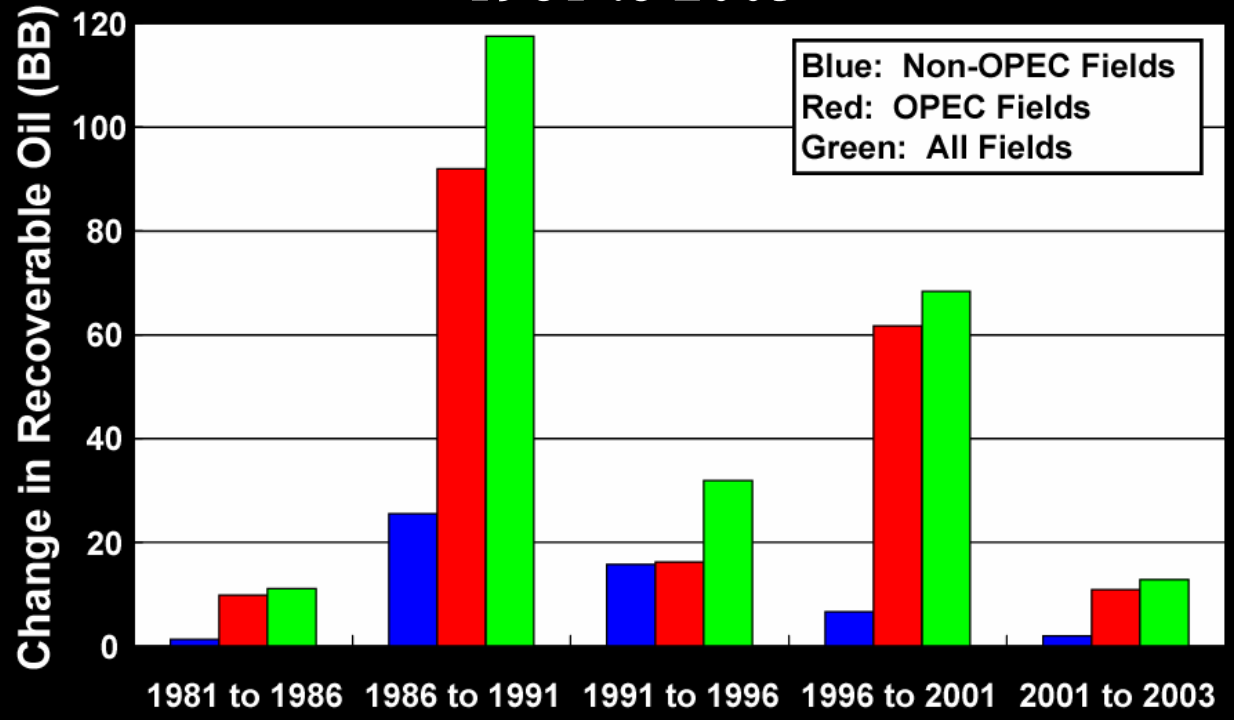
Reserve Growth
Magnitude

- 1981 to 2003
  - New-field discoveries and reserve growth of 186 giant oil fields will supply World for 14 years (7 years each)
- 1997 to 2003
  - New-field discoveries and reserve growth of 186 giant oil fields will supply World for 5 years (2 and 3 years, respectively)

– Assuming World consumption at 28 BB per year, as reported for 2001 (Degolyer and MacNaughton, 2003)

Changes in Reserve Growth Through Time

Change in Recoverable Oil Volumes in 186 Giant Oil Fields, 1981 to 2003

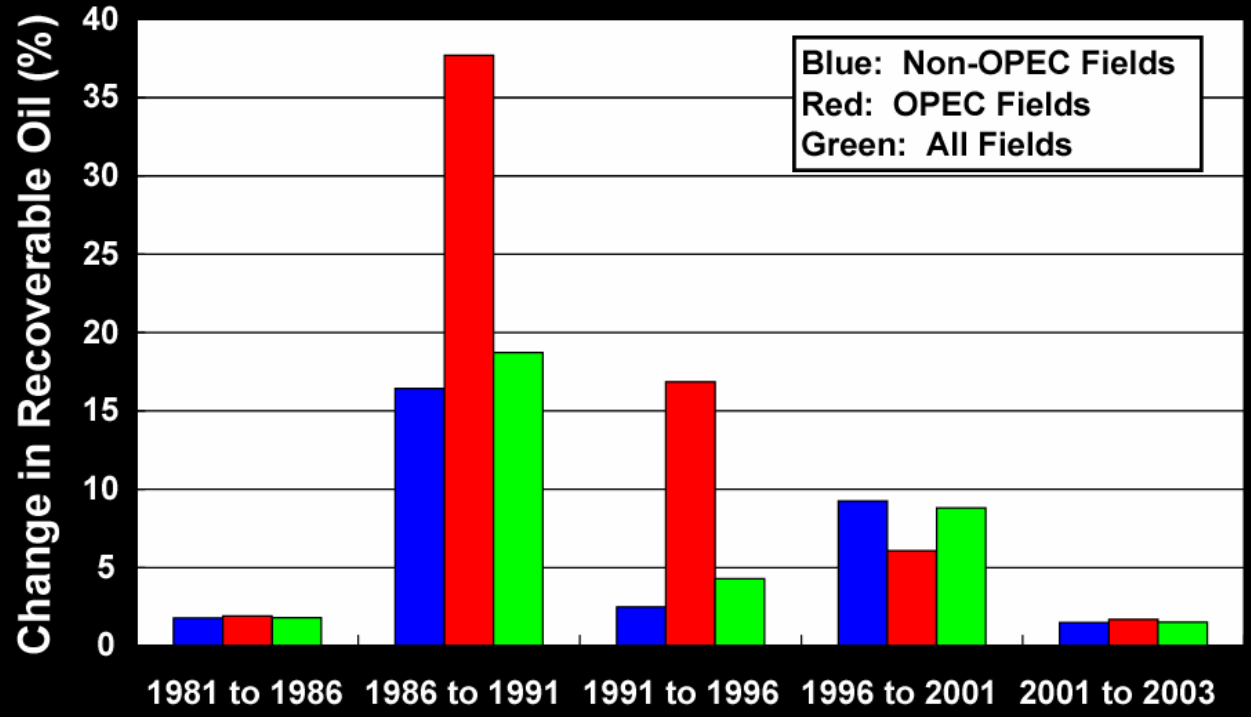


From Klett and Schmoker (2001, 2003); Klett, Charpentier, Schmoker, and Attanasi (2000)

Data from IHS Energy Group (1981 to 2003)

Changes in Reserve Growth Through Time

Percent Change in Recoverable Oil in 186 Giant Oil Fields, 1981 to 2003



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Data from IHS Energy Group (1981 to 2003)

Reserve Growth
Significance

- Observed worldwide
- Makes up significant portion of resources
- Reported reserves change through time
- Political and business decisions are made on reported reserves
  - Economic and strategic security
  - Decisions can be in error if changes in reported reserves are not considered

Reserve Growth

U.S. Geological Survey Studies

- Reserve growth models
  - Additions to existing fields
  - Sizes of undiscovered accumulations
- Specific (custom) models
  - Magnitude and significance
  - Homogeneous populations of data
  - Independent variables

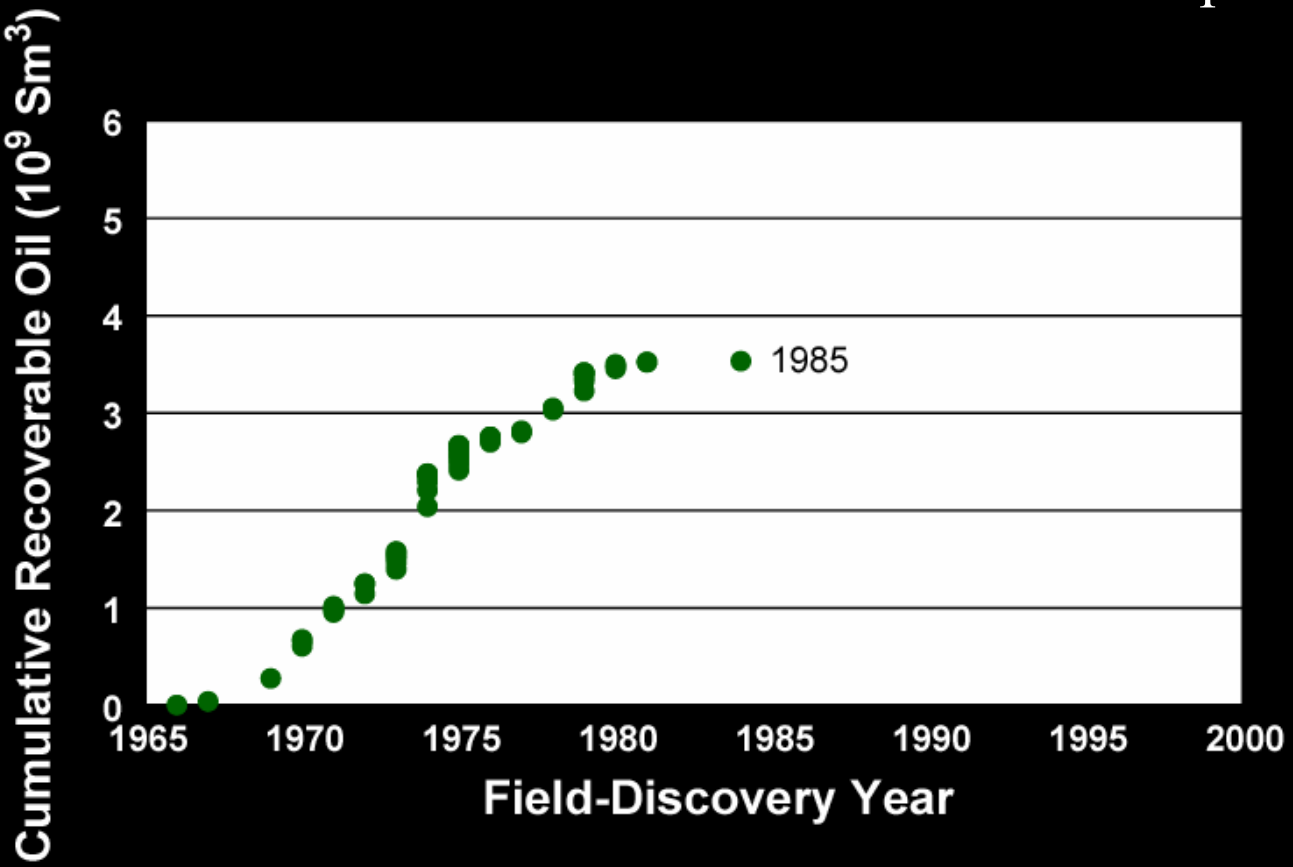
Reserve Growth
U.S. Geological Survey Studies

- North Sea fields
  - Excellent data set
  - Comparison
  - Analog

North Sea Oil Fields

1985 to 2000 (15 years)

Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 1985

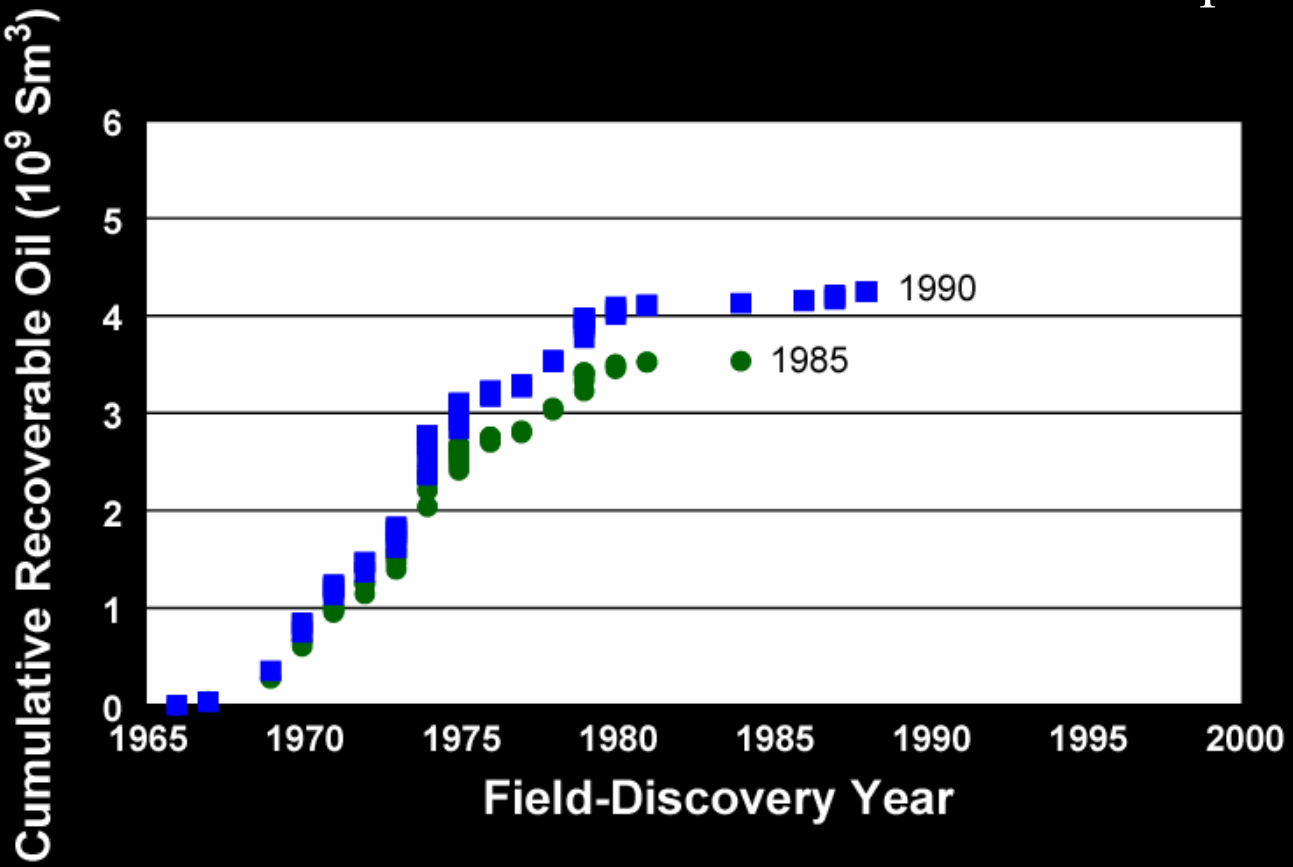


Data from DEA, DTI, NPD (1985 to 2001)

North Sea Oil Fields

1985 to 2000 (15 years)

Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 1990

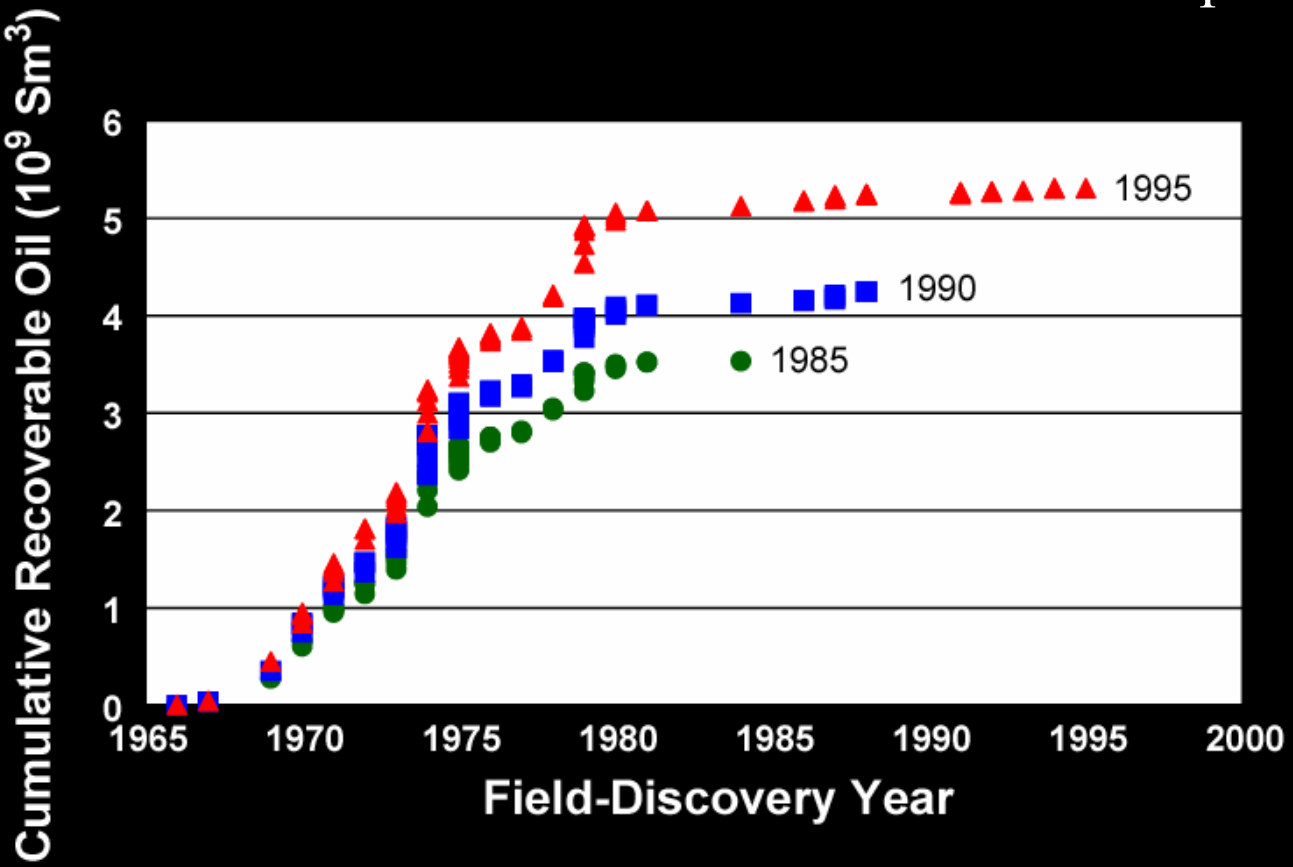


Data from DEA, DTI, NPD (1985 to 2001)

North Sea Oil Fields

1985 to 2000 (15 years)

Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 1995



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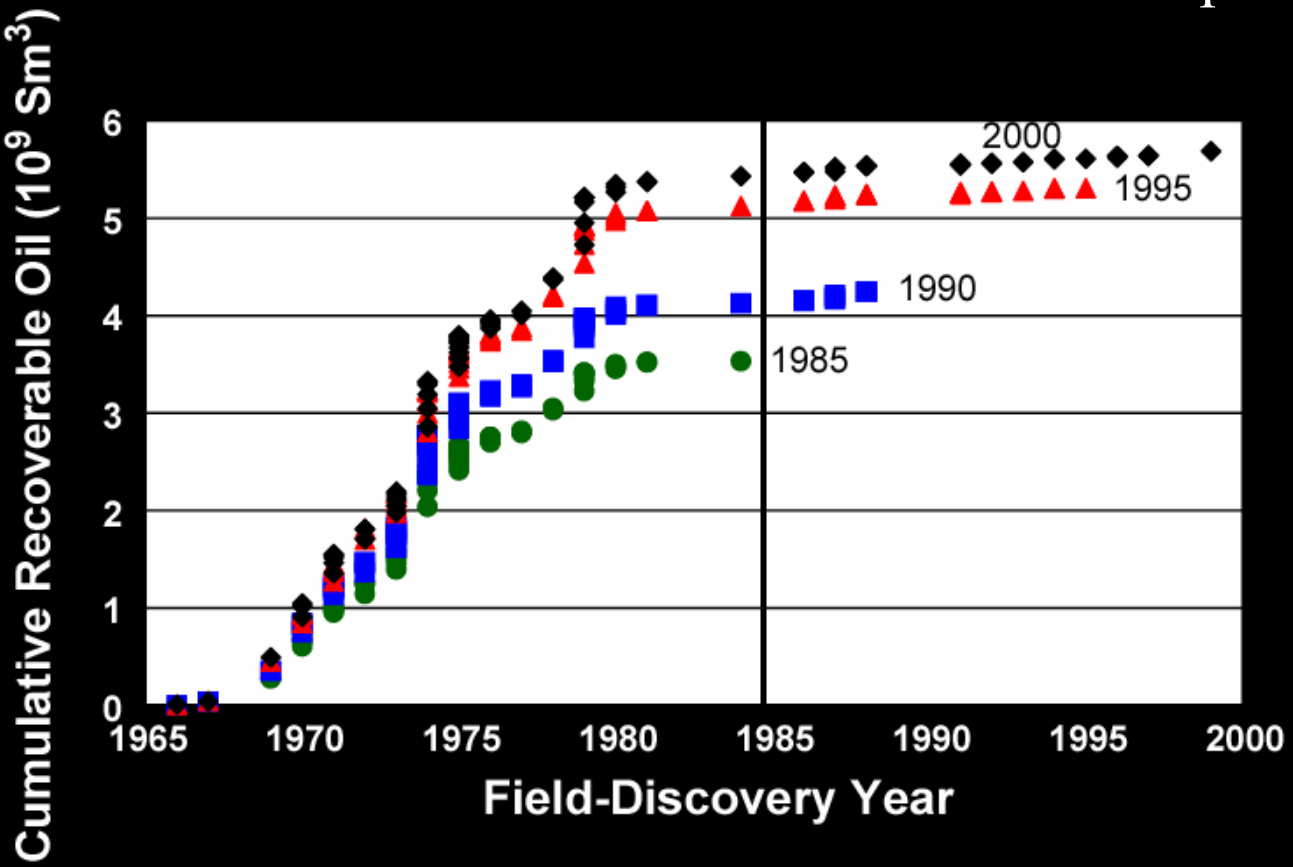
North Sea Oil Fields

1985 to 2000 (15 years)

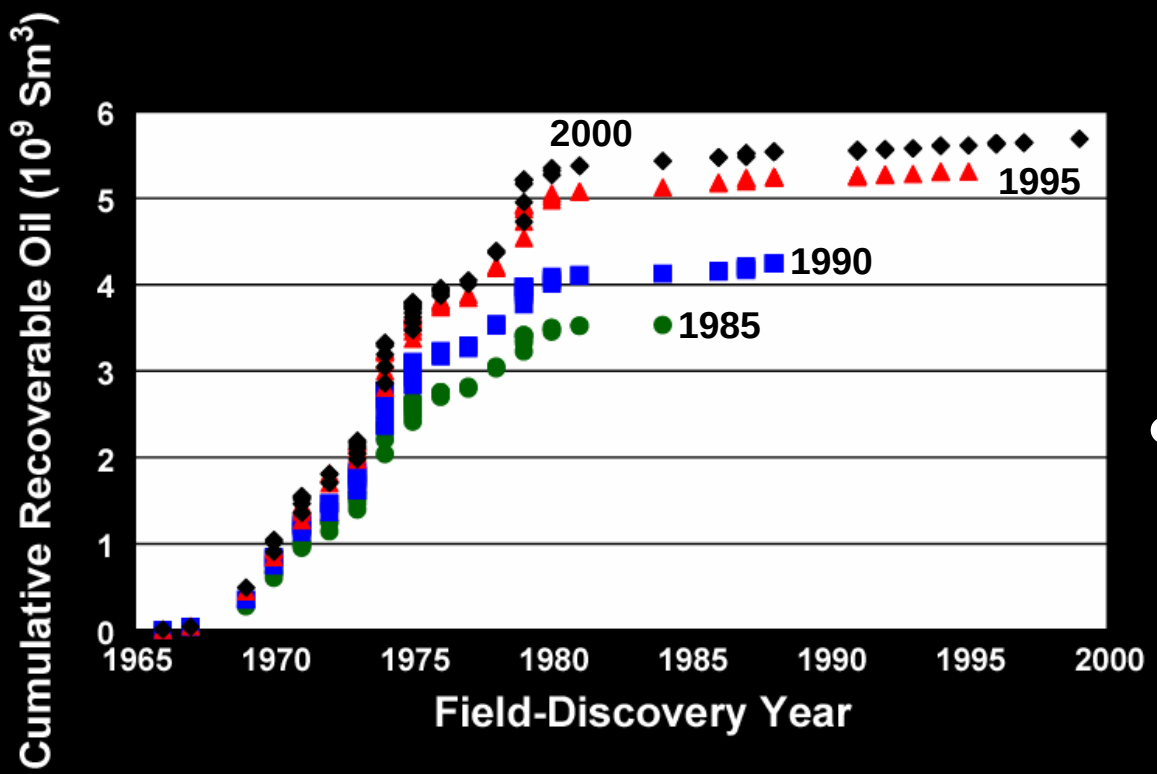
Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 2000



Data from DEA, DTI, NPD (1985 to 2001)

Magnitude of Reserve Growth

North Sea Oil Fields – 1985 to 2000 (15 years)



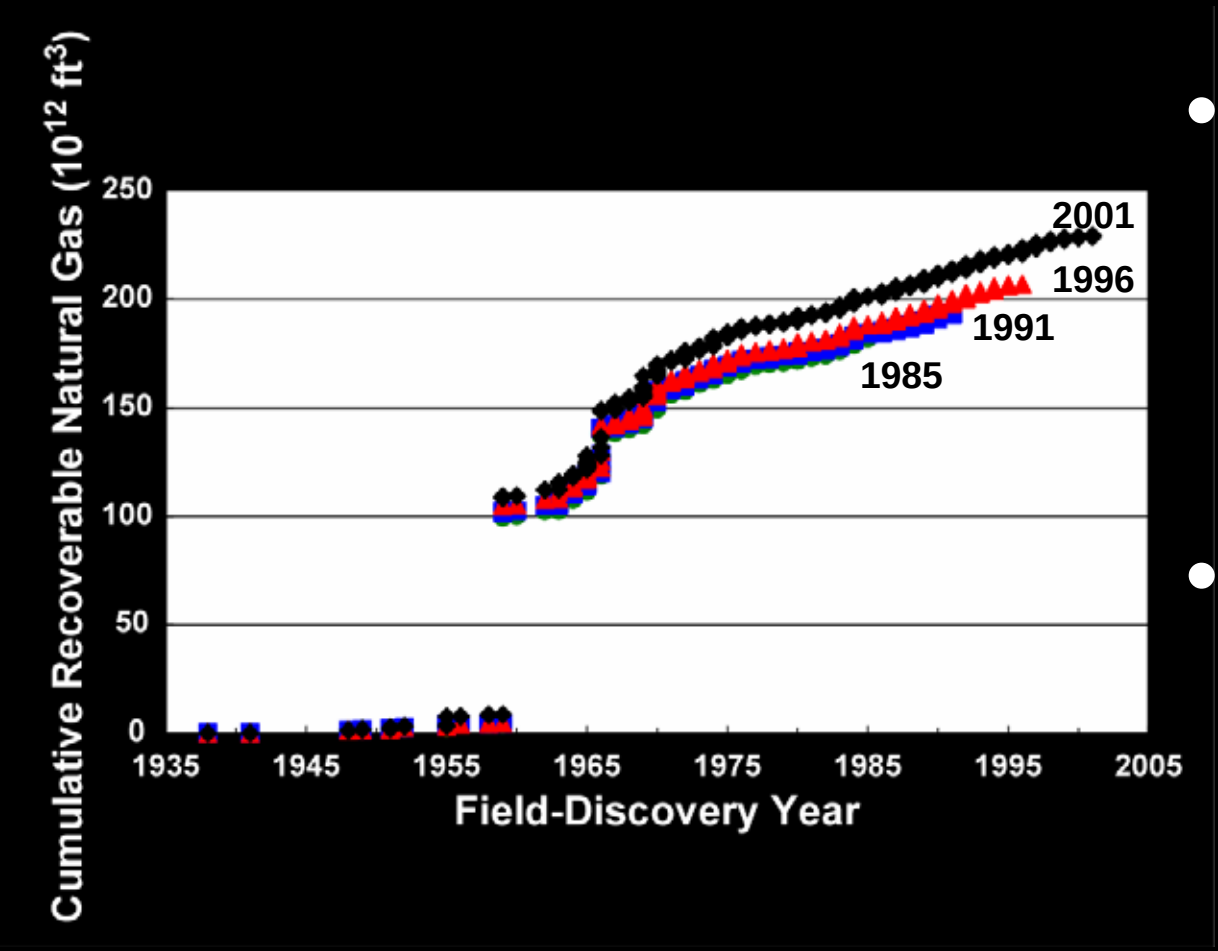
Data from DEA, DTI, NPD (1985 to 2001)

- Reserve growth
  - $1.9X10^9$ Sm^3 ($12X10^9$ bbls) added since 1985
  - 57 existing oil fields
- New-field discoveries
  - $0.3X10^9$ Sm^3 ($2X10^9$ bbls) added since 1985
  - > 25 oil fields discovered after 1985

USGS Greatest volume increase (reserve growth) from 1990 to 1995

Magnitude of Reserve Growth

Southern North Sea Gas Basin Fields – 1986 to 2001 (15 years)



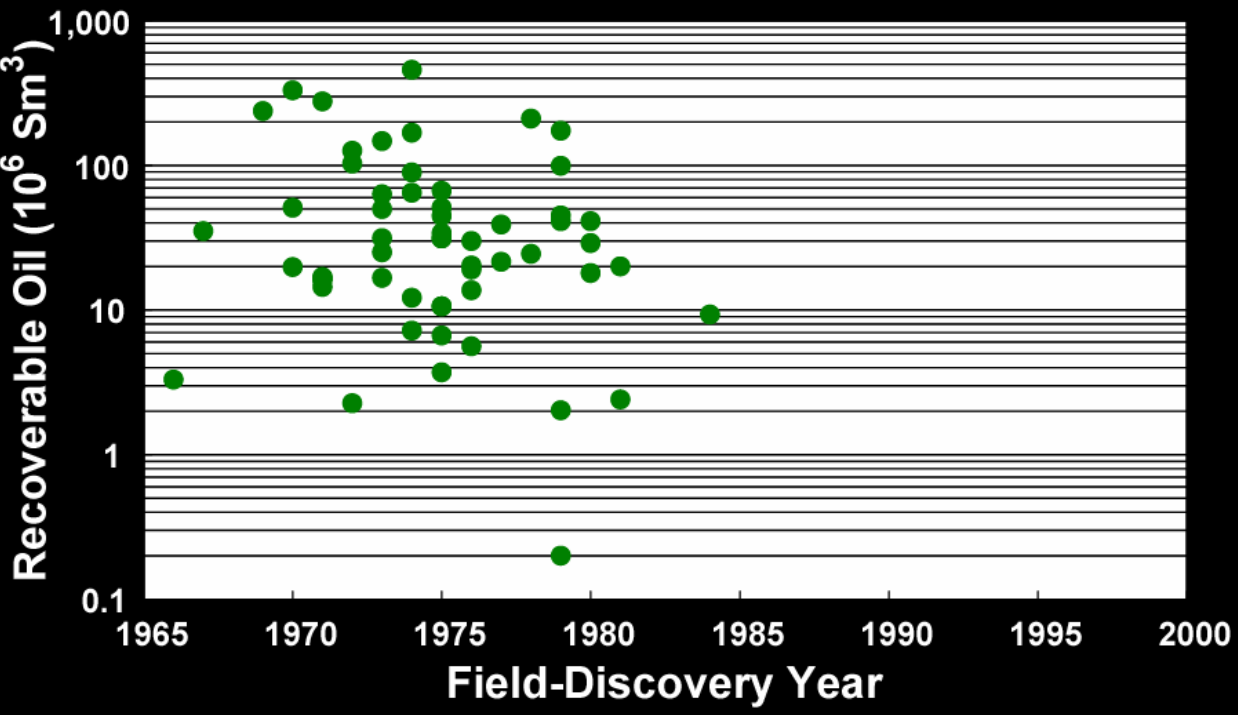
Data from IHS Energy Group (1986 to 2001)

- Reserve growth
  - 19X10^{12} ft^3 (0.5X10^{12} Sm^3) added since 1986
  - 240 existing gas fields
- New-field discoveries
  - 28X10^{12} ft^3 (0.8X10^{12} Sm^3) added since 1986
  - > 259 gas fields discovered after 1986

Application of Reserve Growth Models

Oil-Resource Assessments

Recoverable Oil Volumes in Oil Fields as Reported in 1985



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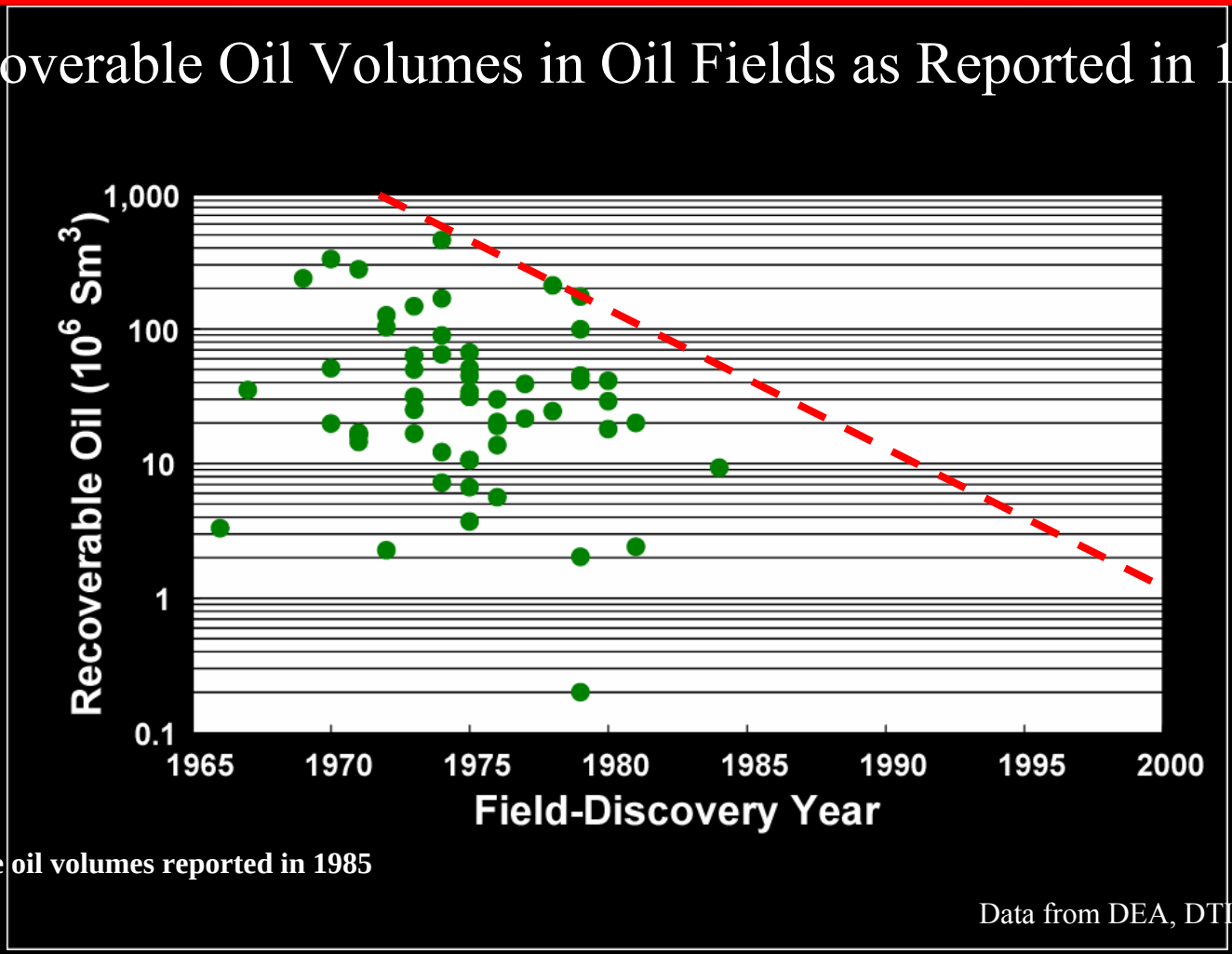
Application of Reserve Growth Models

Oil-Resource Assessments

Recoverable Oil Volumes in Oil Fields as Reported in 1985



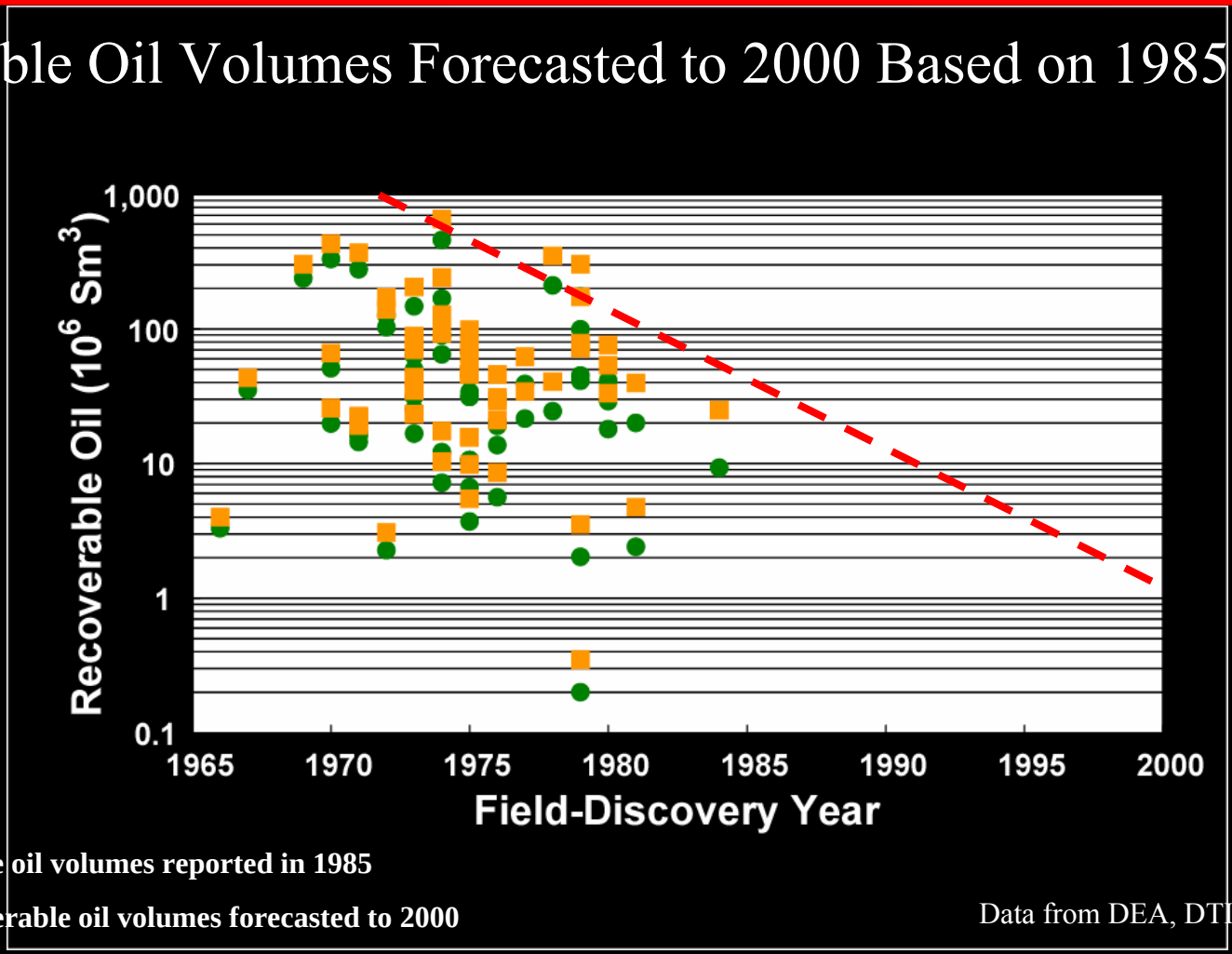
Green: Recoverable oil volumes reported in 1985

Data from DEA, DTI, NPD (1985 to 2001)

Application of Reserve Growth Models

Oil-Resource Assessments

Recoverable Oil Volumes Forecasted to 2000 Based on 1985 Volumes



Green: Recoverable oil volumes reported in 1985

Yellow: 1985 recoverable oil volumes forecasted to 2000

Data from DEA, DTI, NPD (1985 to 2001)

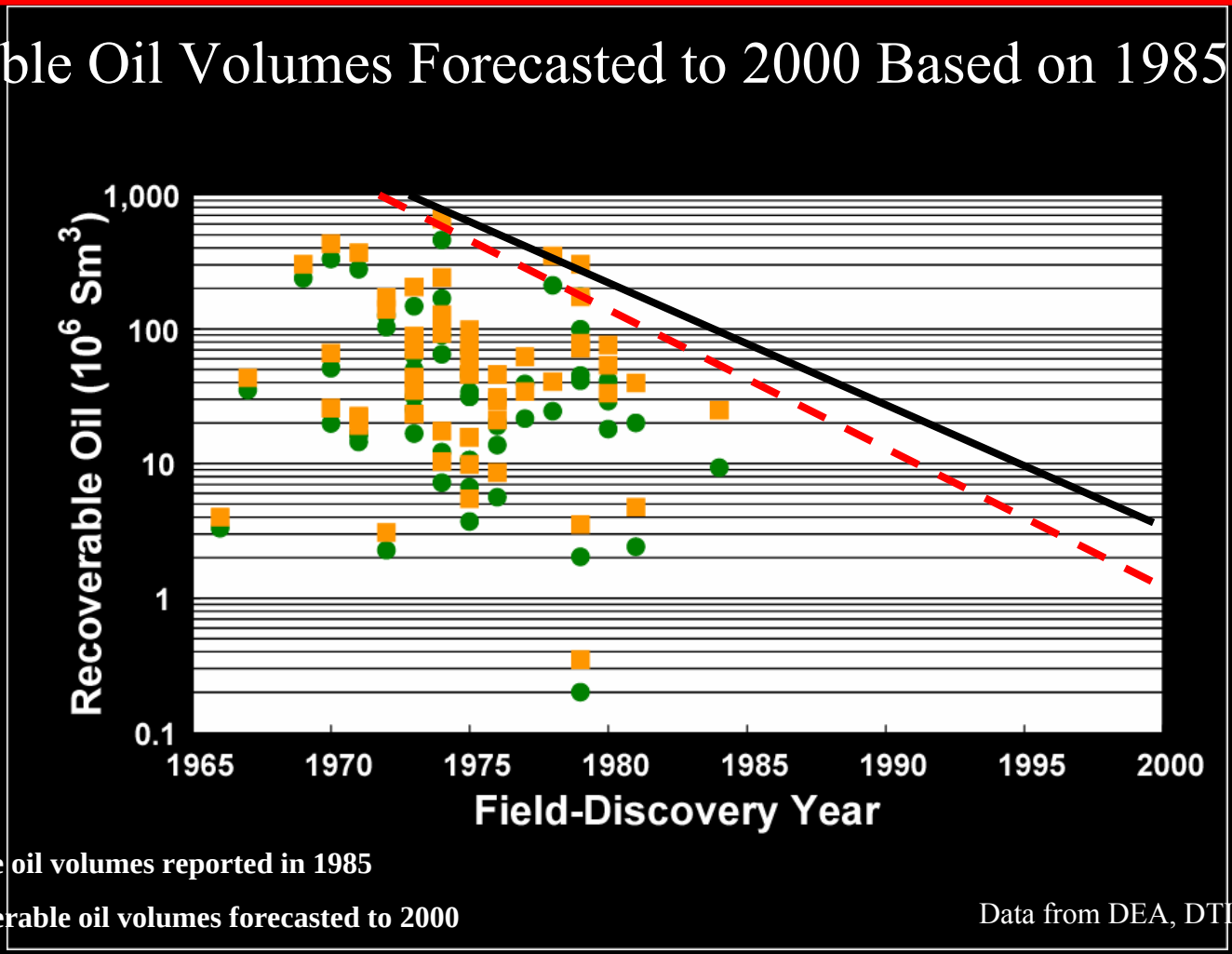
USGS

Reported volumes may be forecasted to a future size

Application of Reserve Growth Models

Oil-Resource Assessments

Recoverable Oil Volumes Forecasted to 2000 Based on 1985 Volumes



Green: Recoverable oil volumes reported in 1985

Yellow: 1985 recoverable oil volumes forecasted to 2000

Data from DEA, DTI, NPD (1985 to 2001)

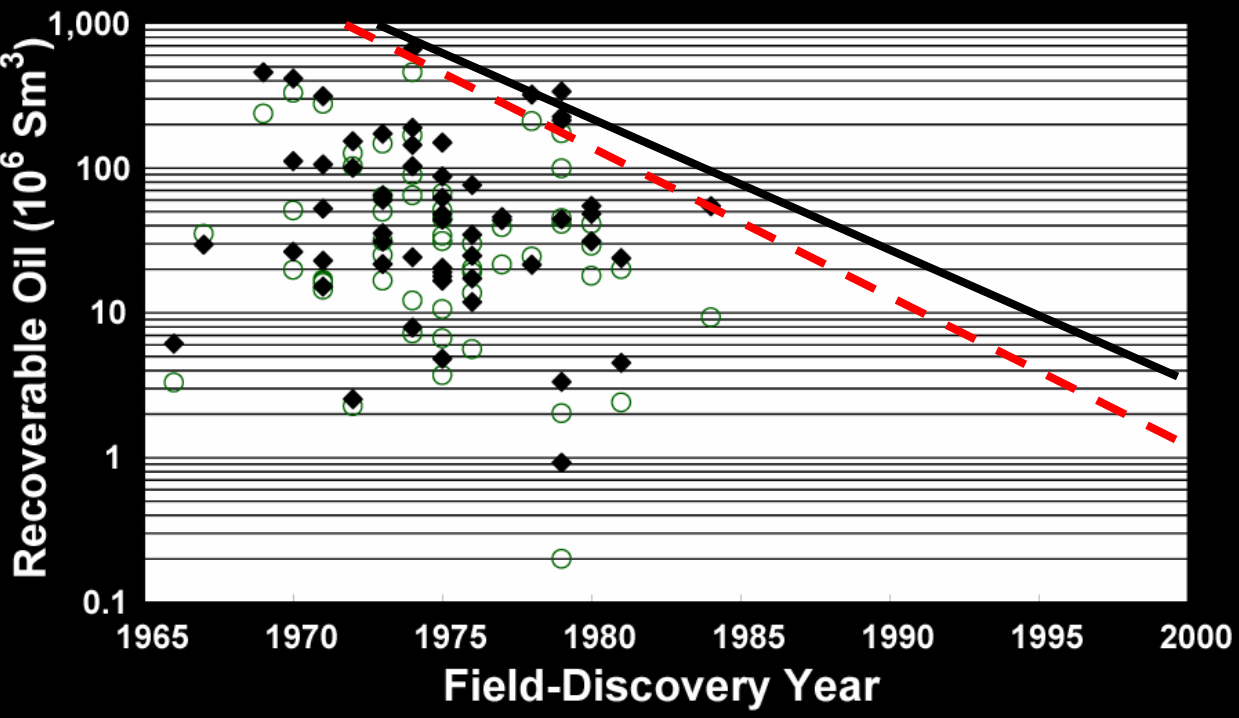
USGS

Extrapolations are made on forecasted sizes

Application of Reserve Growth Models

Oil-Resource Assessments

Recoverable Oil Volumes in Oil Fields as Reported in 2000



Open: Recoverable oil volumes reported in 1985

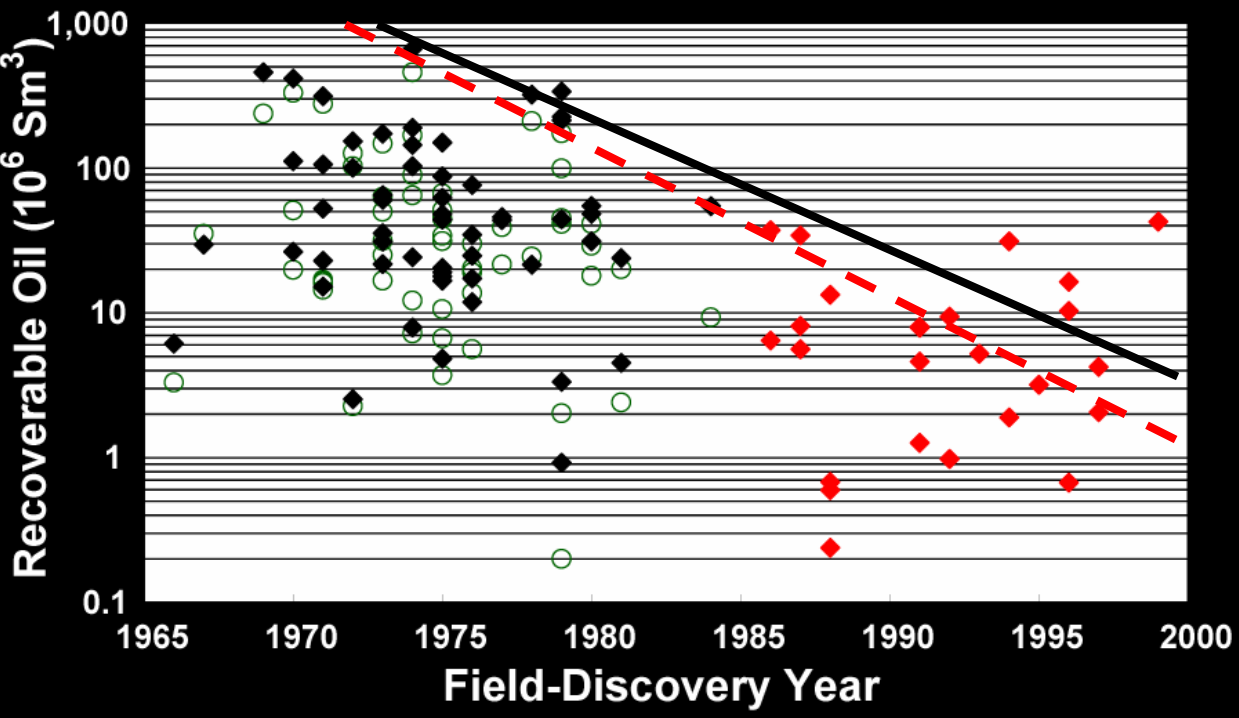
Solid: Recoverable oil volumes reported in 2000

Data from DEA, DTI, NPD (1985 to 2001)

Application of Reserve Growth Models

Oil-Resource Assessments

Recoverable Oil Volumes in Oil Fields as Reported in 2000



Open: Recoverable oil volumes reported in 1985

Solid: Recoverable oil volumes reported in 2000

Data from DEA, DTI, NPD (1985 to 2001)

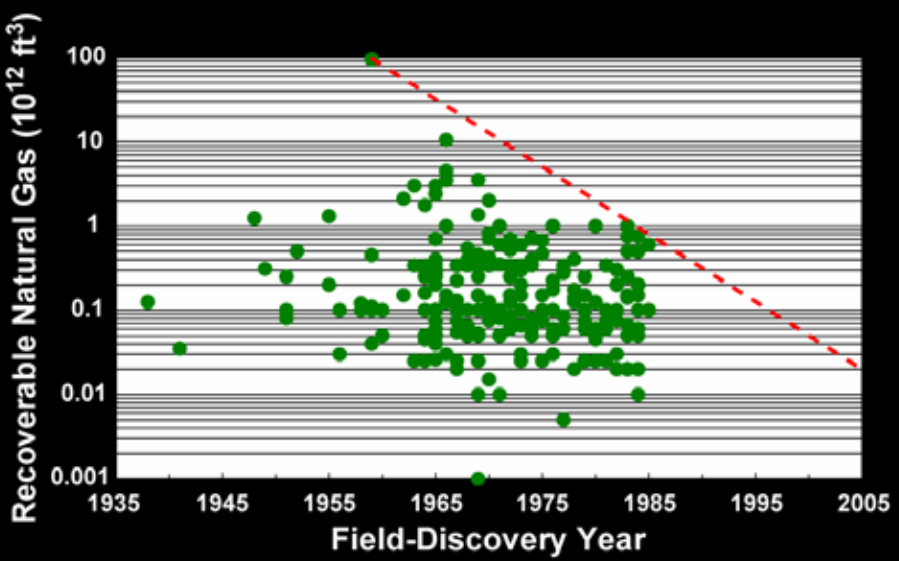
USGS

Extrapolations based on forecasted sizes provide better estimates

Application of Reserve Growth Models

Natural-Gas Resource Assessments

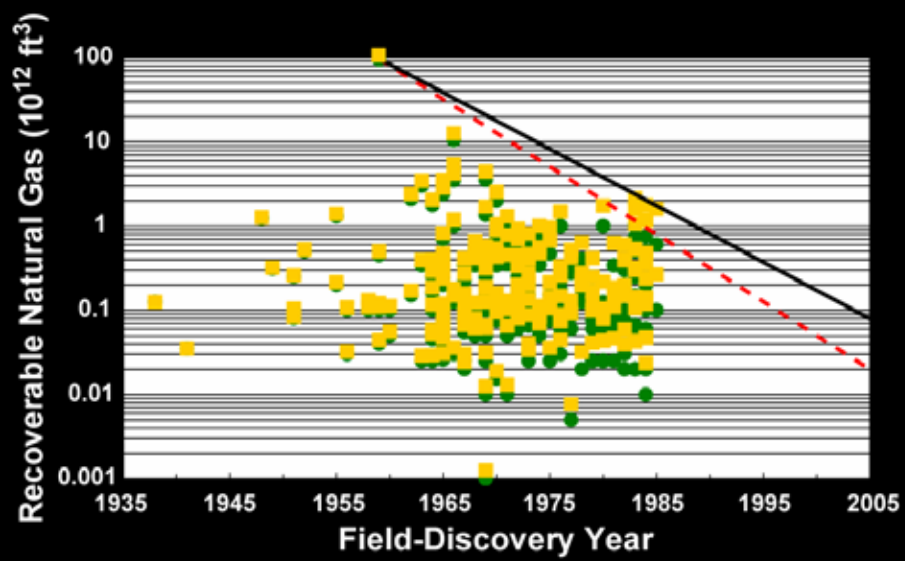
Recoverable natural-gas volumes as reported in 1986 and extrapolated line for enveloping undiscovered fields



Green: Recoverable oil volumes reported in 1985

Yellow: 1985 recoverable oil volumes forecasted to 2000

Forecasted recoverable natural-gas volumes with envelope based on 1986 volumes forecasted to 2001



Data from IHS Energy Group (1986 to 2001)

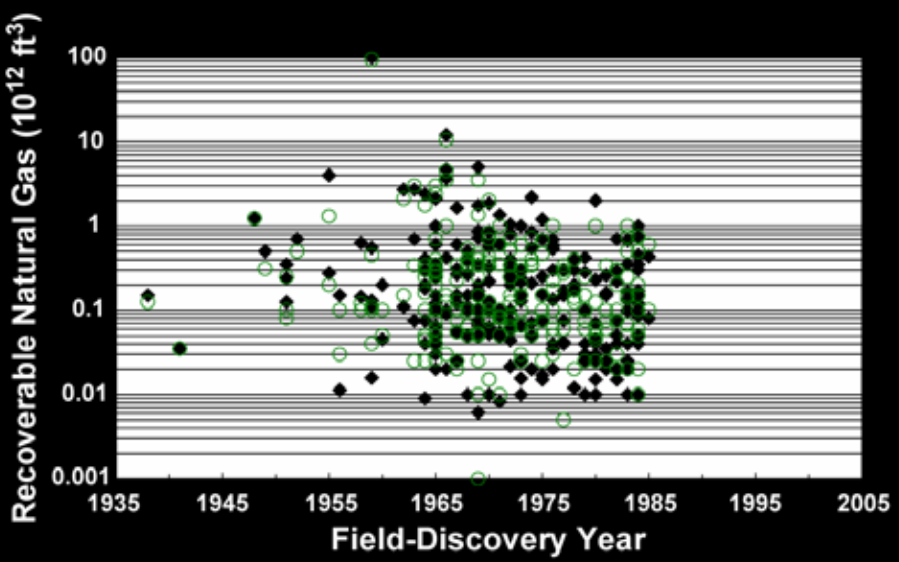
USGS

Envelope adjusted upwards based on forecasted 2001 field volumes

Application of Reserve Growth Models

Natural-Gas Resource Assessments

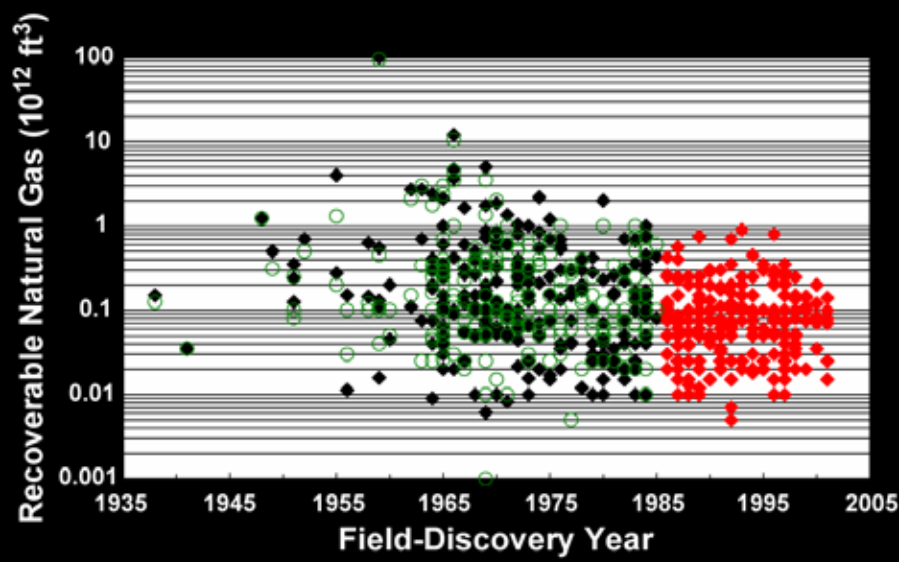
Recoverable natural-gas volumes in gas fields discovered before 1986 as reported in 2001



Open: Recoverable oil volumes reported in 1985

Solid: Recoverable oil volumes reported in 2000

Recoverable natural-gas volumes in gas fields discovered before and after (new fields) 1986 as reported in 2001



Data from IHS Energy Group (1986 to 2001)

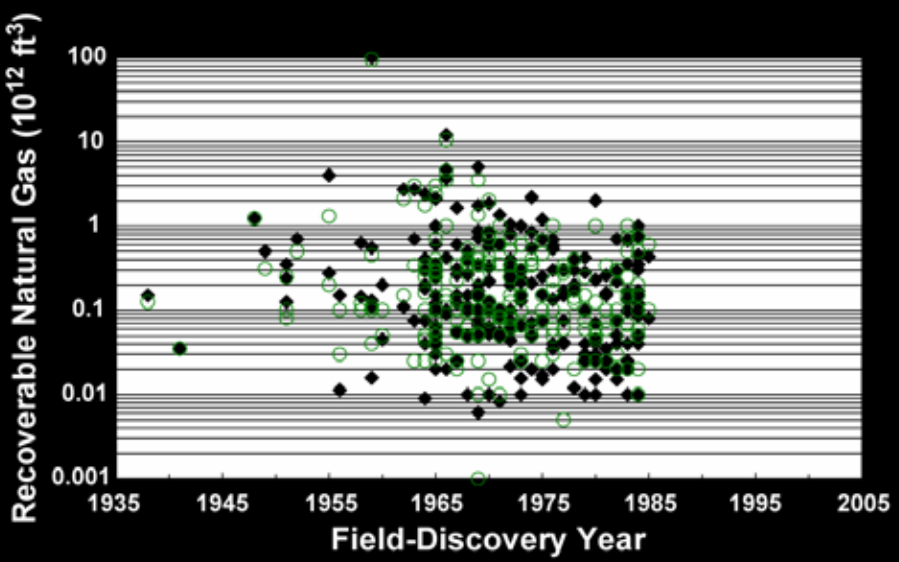
USGS

Volumes of individual fields are variable, some decreasing

Application of Reserve Growth Models

Natural-Gas Resource Assessments

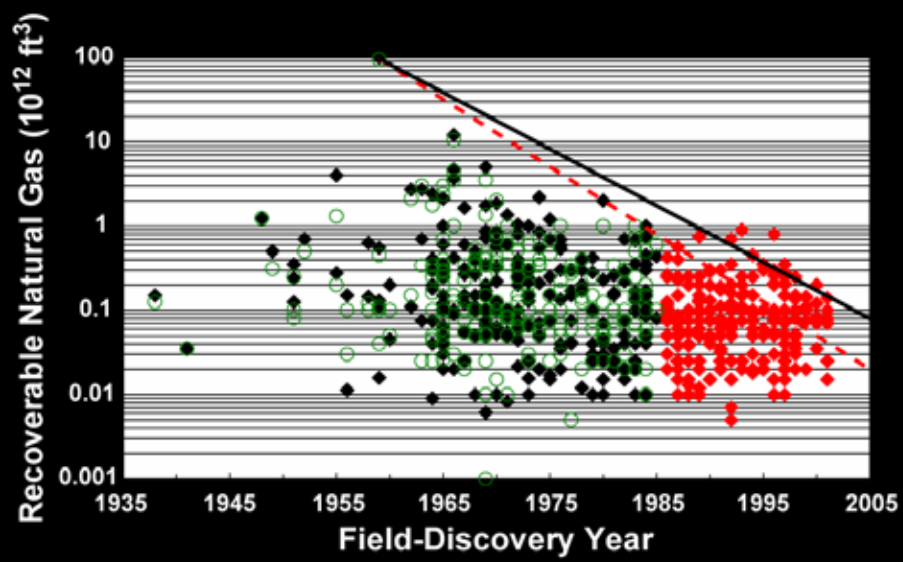
Recoverable natural-gas volumes in gas fields discovered before 1986 as reported in 2001



Open: Recoverable oil volumes reported in 1985

Solid: Recoverable oil volumes reported in 2000

Envelopes based on 1986 reported and forecasted volumes



Data from IHS Energy Group (1986 to 2001)

USGS

Envelope adjusted for reserve growth provides better estimates

Future Petroleum Supply
Conclusions

Point Lobos, California
Photograph courtesy of Ken Takahashi, USGS

- New-Field Discoveries
  - Smaller volumes in mature areas
  - Contribute more upon opening of new areas for exploration

Future Petroleum Supply
Conclusions

Midway-Sunset Field, California
Photograph courtesy of Ken Takahashi, USGS

- Reserve growth
  - Significant
  - Magnitude is comparable to new-field discoveries
  - Make up significant portion of the world's resources

Reserve Growth

Conclusions

first break volume 21, November 2003 news feature

Report finds most new oil around the world comes from old fields

Anyone looking for an upturn in the exploration business is likely to be disappointed by the latest set of figures from IHS Energy in its annual report on 10-year trends in oil and gas E&P. We publish the highlights here with comments from one of its authors.

First Break (2003)